Impact of C4ISR/Digitization and Joint Force ability to conduct the Global War on Terror

A Monograph

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14. ABSTRACT

The end of the Cold War marked the end of an era in United States national security. The bipolar global balance of power, which defined our nation's defensive strategy for more than 30 years, was replaced with the uncertainty of failed nation-states, rogue authoritarian regimes, and international terrorist organizations. Operations in the late twentieth century and early twenty first cnetury have been characterized by a dramatic increase in the use of C4ISR systems, transformation initiatives, and network-centric warfare concepts. Joint and Coalition forces showed how effective these systems, initiatives, and concepts can be during major combat operations in Iraq and Afghanistan. A theory of technological synergy is used to describe changes in effectiveness through implementation of technology and organizational change. Multiple systems from space, to aircraft and UAVs, to ground systems are required to empower the Joint Force. Through the successful implementation of these systems, a global C4ISR structure can be described as the primary enabler that empowers Joint Forces to successfully conduct the Global War on Terror.

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Abstract

Impact of C4ISR/Digitization and Joint Force ability to conduct the Global War on Terror (GWOT), by Major Andrew P. Dacus, U.S. Army, 66 pages.

The end of the Cold War marked the end of an era in United States national security. The bi-polar global balance of power, which defined our nation's defensive strategy for more than 30 years, was replaced with the uncertainty of failed nation-states, rogue authoritarian regimes, and international terrorist organizations. A new world was emerging with the rapid increase in computer technology, the internet, satellite communications, and global economic markets. In 1991, the United States conducted its first major conventional war using smart bombs, Global Positioning Systems (GPS), satellite communications, and space-based imagery technology. These systems were further refined during operations in Bosnia, Kosovo, Haiti, and Somalia. Joint Forces were being deployed to all parts of the globe in ways that had not been anticipated before, and the concept of employing a large conventional force was largely becoming too cumbersome and obsolete. A lighter and more rapidly deployable force that provided the same lethal capabilities was required to meet the new challenges of the twenty first century.

The Chief of Staff of the Army, General Eric Shinseki, provided a vision of force transformation in order to meet the new challenges for the future. One of the main concepts that emerged as an essential component of force transformation was the ability to achieve information dominance through network-centric warfare. The new paradigm of being a Joint Expeditionary Force that is more rapidly deployable, adaptive, lethal, and able to bring all Joint Force capabilities to bear in any given operation requires the technology that will provide commanders the ability to see the enemy first, understand the situation, and take decisive action. Whether it was low-intensity combat, humanitarian relief, counter-insurgency/counter-terrorist operations, or major combat operations, adapting to new policy demands set the stage for the deployments to Afghanistan and Iraq following the attack on the World Trade Center towers on September 11, 2003. The successful application of digital systems during Operations Enduring Freedom (OEF) and Iraqi Freedom (OIF) provided the construct and direction that Joint Forces would continue to pursue, as they marched toward the concepts of Joint Vision 2020 while continuing to fight the Global War on Terror.

A theory of *technological synergy* is used as the method to identify the evidence supporting the need for technology change in the organization. The evidence is provided by analyzing the theory of *technological determinism* on one extreme and *social construction* on the other. Even though both of these theories have proven to be valuable in describing technological advances in America in the past, there is a more thorough way of describing how the complexity of multiple forces are brought to bear in the development of these systems. The forces of social organization, culture, advances in technology, and external threats are all inter-related and work together to drive change in the organization. The successful implementation of modern digital systems, provided by the network-centric concept, is a critical component to empowering organizational change. On the other hand, a successful organizational change, provided in the Joint Vision concept, is a critical component to the application of digital C4ISR systems. There is a synergistic effect when technology is integrated and synchronized horizontally into the organization, and when successfully applied, validates the organizational changes being made. Moving the organization from the slower analog model to the new digital model allows the organization to adapt rapidly to change. A global C4ISR structure is the backbone that enables the United States military to conduct the Global War on Terror in a more efficient manner.

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INTRODUCTION

Throughout history, military commanders have sought for an advantage over their enemies. In this search for an advantage, the ability to see the battlefield, communicate with all the relevant forces and understand the nature of one's opponent has been critical to the successful command and control of military forces. The term Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) is a modern term that describes the systems that enable Joint Force Commanders to gain situational awareness over the enemy, while maintaining the freedom to maneuver forces in a dominant and decisive manner. Digital technology and the popularity of the internet have had an impact on the current technological change the military is facing today. This change is being fueled by the "Net Generation", or those people who were born after 1977 and who are educated and confident with using modern digital technology.[1] The theories of *technological determinism* and *social construction* can both be argued as to whether or not technology is the agency of change, or if social factors and organizational design creates the technological advancement.[2] The theory of *technological synergy* better describes the fact that technology and society interact with each other to create change. In order for society to accept technological change and allow it to develop into something beneficial, there must be a perceived value in the use of the new technology that makes society and organizations better. These perceptions must eventually be realized in an increase of efficiency in the workplace, better way of life for the individual or greater military capability.

[1] Don Tapscott, *Growing Up Digital: The Rise of the Net Generation* (New York: McGraw-Hill, 1998), 3.

[2] *Technological determinism* is the belief that developments in technology determine change in an organization, versus the idea of *social construction*, which presumes that changes occur primarily due to social and cultural change.

With the fall of the Soviet Union, the nature of the threat facing the United States and its allies has changed significantly. Rogue regimes and failing states that support terrorist organizations is the threat the United States faces in the twenty-first century. Traditional threats like Russia and China are still a concern, but with the ever-increasing globalization of the marketplace, these countries are becoming partners in a global economy and allies in the Global War on Terror (GWOT). The nature of this threat has made an impact around the world. Terrorist organizations and rebel groups are preaching their particular brand of hate to incite violence against civilian targets like modern society has never seen before. In a world with so much potential to prosper, the forces of terror strive to take a giant leap backwards into the Middle Ages – the perceived glory days of their radical Islamic society. Rather than embracing education and economic development in order to prosper, they put their heart and soul into planning and conducting attacks against the modern world. The haves and have-nots still exist in the world, as they have for thousands of years. This is a reality that will probably never change, and is one of the primary reasons that radical ideology has flourished in certain societies.

Dangerous mass movements have originated through the teachings of men like Carl Marx, who advocated a particular brand of socialism that aroused the poor working classes in Europe. Marx believed that social class distinctions should be abolished and that all personal possessions should be removed from individuals and given to the state for the good of society. Over one third of the world currently follows his teachings through Communism, Socialism, Marxism, and Fascism. The ideology of Marx, Lenin, Hitler and Mao all flourished during the twentieth century, and the subsequent mass movements of communism and fascism are what led the United States into the World Wars and Cold War. The failed states and left-over cold war regimes are the result of the negative effects that ill-conceived mass movements can have on a society. The effect of radical ideology and mass movements attract the "have-nots" primarily, with the "haves" as their leaders. Men like Osama Bin Laden, the son of a wealthy Saudi Arabian

construction magnate, is an example of how terrorist leaders who seek to achieve power through radical ideology prey on the young and impressionable to build their organizations.

Eric Hoffer, in his book *The True Believer*, describes the type of individual that is attracted to mass movements and focuses on the active-revivalist phase of a movement. The individuals attracted to these movements are usually the frustrated, poor, and downtrodden with nothing that motivates them in life. They are willing to sign-up for any cause that helps them forget their miserable mental or physical condition and that brings them into the fold of a worthy cause. Hoffer says that the active mass movement attracts "the man of fanatical faith who is willing to sacrifice his life for a holy cause".[3] The danger lies within the doctrine and teachings of the mass movement. The radical true believer hates the present state of affairs and is ever striving for the great future – in the case of radical Islam, they are promised a paradise in heaven with dozens of virgin maidens at their service. The true believer hates himself, his current situation in life, and is ready to die to escape the present and contribute to the cause he has joined.

The enemies of freedom and democracy understand the fact that they are out-matched technologically by the United States and its allies. The 1991 Gulf War was a demonstration of how a less capable conventional threat can be defeated in only 100 hours using the combined power of the joint force. Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) were even further examples of how the US dominates the electromagnetic spectrum. Space force assets, aircraft platforms, and ground sensors have evolved to the point that the idea of a global C4ISR architecture is not only possible, but it is happening right now in the early twenty first century. The space force assets that the U.S. and its allies possess, combined with the planes, unmanned aerial vehicles, and myriad of ground sensors are critical to current commanders on the ground. Commanders from OEF and OIF are demanding more C4ISR capability as they execute the GWOT. Capabilities that were typically reserved for Special Forces or strategic levels of

[3] Eric Hoffer, *The True Believer* (New York: Harper and Row Publishers, 1951), Preface, ix.

command during the Cold War are spiraling out into the conventional joint force with rapid fielding initiatives and commercial off-the-shelf (COTS) technology. The fact that the enemy is more dispersed and operating in austere environments requires accurate and timely intelligence, deployable and rugged SATCOM capabilities, and theater to strategic ISR assets to conduct the mission. This requires a C4ISR architecture that is networked with the power of digital technology, and not stove-piped like the slower analog architectures of the cold war. It also requires funding in the billions of dollars to build and maintain, like MILSTAR Extremely High Frequency (EHF) satellites that can transmit secure data during sand storms, and GPS constellations resistant to jamming that can provide highly accurate positioning data for precision-guided munitions. These capabilities are not just "pipe dreams" that commander's hope to get "chopped" down to them in the task organization. These are capabilities that are required in today's joint force construct, and are also the key enablers of the future network-centric force under Joint Vision 2020.

The foundation of modern digital networks is a fiber-optic cable system, which allows much more information to travel at much faster speed between ground stations. The perfect example of meeting current technological expectations at home is when a personal computer user changes from dial-up technology to digital internet technology. The difference is incredibly faster access to much more information. Development of the microprocessor is another component that has allowed information to be transferred and processed much more rapidly than previous computer systems. Digital imagery, video technology, and voice over internet protocol (VOIP) are all rapidly developing services that both domestic and military users demand in the Net Generation. One of the risks of this technology is that troops who are deployed can use email and satellite phones to transmit messages and images that can be intercepted and used by anti-coalition forces or the media. In addition, when young soldiers are not properly trained on Operational Security (OPSEC), or succumb to unethical influences like Abu Ghraib, the impact

on US forces can be strategically damaging and make it extremely difficult to recover the ethical high ground.

Despite the negative aspects of modern digital technology, the benefits do outweigh the risks. Securing modern digital C4ISR lines of communications is critical to maintaining a global strike capability, as well as enabling US joint forces to rapidly deploy and project forces where they are needed. US forces must use every technological advantage to their benefit, to include a global C4ISR network that not only links joint forces and coalition forces, but can also link law enforcement with the military. In the event of another terrorist attack on US soil requiring a large scale joint civil-military response, no exercise or virtual training event will fully prepare local officials and military forces for every possible scenario. The primary way to bring some form of order to the chaos is to have a reliable C4ISR network that local, federal, and military responders can plug into. The recent example of how a natural disaster can negatively affect networks is Hurricane Katrina in New Orleans. Imagine how much more complex and devastating the catastrophe would have been if a terrorist cell had driven a truck into the Superdome with a radiological dirty bomb. However, it should not take another catastrophic event to stimulate political and military leaders to provide the enabling technologies required by first responders, local, state, and federal organizations to keep this country safe and secure.

The challenge with C4ISR in the current joint force architecture is networking information between all communications platforms, so that the commanders can use the information and organize their forces to achieve a synergistic effect. The synergy of a network-centric force that is linked to critical C4ISR information is indeed happening, and the national agencies like the National Reconnaissance Office (NRO), National Security Agency (NSA), National Geospatial Agency (NGA), United States Space Command, and many others are committed to providing accurate and timely support to the warfighter. Without the space-based support from national agencies, and without the Air Force to operate joint space-based assets, the network-centric concept of warfare would not be possible. Ground stations must be linked to a

capable and durable satellite constellation, which requires constant attention due to the effects of space weather on space platforms. Once the satellites are placed into orbit, they are managed by Space Command and tasked according to the requirements of national security and the geographic combatant commander's needs. The space segment is transmitted into the theater C4ISR architecture, which is then distributed accordingly to joint forces. This is what is known as the Global Information Grid (GIG), a system of systems that will allow C4ISR information to flow virtually anywhere, anytime, and under the most adverse of conditions. The process is much more complicated than this simple explanation, however, it is important to understand that the system of systems design for the future force concept is being designed from the ground up, in order to link sensor to shooter platforms in the C4ISR network to produce a synergistic effect.[4]

By spiraling new technologies into the current force structure, systems are being designed and tested in combat situations under the supervision of Research, Development, and Engineering Command (RDECOM) for conventional Army-unique systems. RDECOM develops new technology to meet the warfighter's needs, in conjunction with the future force concept center at Training and Doctrine Command (TRADOC). Special Operations Command (SOCOM) generally uses its own internal system for research, development, and fielding of new technology. The leaders, scientists, and field operations teams within the R&D community are committed to bringing new capabilities to the warfighter that fill the C4ISR gaps of forces operating within the theater of operations. Technological synergy takes time, money, development, testing, and training to be successful. The software has to be compatible with the hardware, the new ISR capability must meet Joint Force requirements, the national assets supporting from space and CONUS have to be synchronized, and must ultimately translate into mission success. This paper will describe the technological synergy theory that led the US military towards a network-centric force construct, it will provide an overview of current and emerging digitally enhanced C4ISR

[4] Director, Force Transformation, *The Implementation of Network-Centric Warfare*, Office of the Secretary of Defense, 5 January 2005.

capabilities being used in the GWOT, and describe how new systems are developed and fielded using the spiral development process. Finally, the conclusion will provide a description of the overall impact of these new technologies on Joint Forces ability to conduct operations in the contemporary operating environment.

CHAPTER TWO

TECHNOLOGY SYNERGY THEORY

The study of technology as an agent of change in America has its roots in the industrial revolution and the founding fathers, who were the first promoters of technology. Men like Thomas Jefferson and Benjamin Franklin were inventors themselves, and understood the value of science and technology as an agent of change to make a better life in the new world. Realizing that there was so much potential in the area of natural resources, Thomas Jefferson planned and financed the Lewis and Clark expedition, which provided a detailed map of the route to the Pacific and a wealth of scientific information about the natural resources of America. You might say that he was conducting an intelligence preparation of the battlefield using the C4ISR assets available to him at the time (military officers, indigenous people, horses, survey equipment, notebooks and writing utensils) to gain critical information about the country. In order to harness the vast natural resources of the new world, he viewed science and technology as an agent of change for the improvement of humankind, as did Benjamin Franklin. They both believed that scientific knowledge, inventions, and technological advances should be shared with others to improve society as a whole. This was the beginning of a cultural trait that has embedded itself into the psychological DNA of American society, and provides a natural linkage between the value placed on technology and the expectations for cultural and national progress.

Alexander Hamilton and Tench Coxe at the Department of Treasury were both strong proponents of industry, and saw the ability to develop technology as a way to save the nation from oppression. They believed that independence could only be achieved by the wealth and economic strength achieved through industry. Coxe saw machine-based manufacturing as “The means of our Political Salvation”, as stated in a speech in the summer of 1787. He also said, “It will consume our native productions…it will improve our agriculture…it will accelerate the

improvement of our internal navigation…and it will lead us once more into the paths of virtue by restoring frugality and industry."[5] These ideas are clearly supportive of technology as an agent of change, and indeed the early leaders of our country risked their lives to create a new nation that was based on an industrial economy.

So what impact has science, technology, and industry had on the U.S. military? Historically, these factors have had a significant impact in regards to strategic and operational effectiveness. The Civil War provides several examples, such as the development of the rifled musket, which improved the accuracy and range of individual weapons allowing infantry formations to engage the enemy from much greater distances with better efficiency. The development of the railroad allowed large armies to deploy quicker across greater distances, and the quartermaster general was able to sustain these formations much more efficiently. Horse and wagon trains were still required from railroad to encampment locations, but the fact that large armies could maneuver to strategically significant locations in a much more effective manner via railroad allowed commanders such as General Grant the opportunity to develop new ideas about strategy and operational maneuver.

As the railroad expanded westward, the development of the telegraph significantly improved communications between army commanders, which facilitated better dissemination of orders as well as reporting to Washington. As where written messages were previously carried by horse, taking days to make an impact, the telegraph permitted much more timely communications between commanders. Therefore, the decisive factor for Union forces in winning the Civil War was not attributed to just new technological achievements in these areas, nor was it just due to a new type of organization or bold maneuvers to cut through the heart of the South. It was the synergy of technological innovation combined with changes in organizational behavior that ultimately lead to success.

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[5] Leo Marx and Merrit Roe Smith, *Does Technology Drive History?* (Cambridge, MA: Massachusetts Institute of Technology, 1995), 4.

By the late nineteenth century, many Americans viewed progress empowered by technology as a moral imperative. The artwork of John Gast shows an angelic woman flying through the air and leading the path westward, while holding the book of common school in one hand and a telegraph wire in the other, as all the wild animals and Indians ran to clear a path for settlers with their wagons and animals. She also wore the star of empire on her forehead, which the natives could not bear to look upon due to its overwhelming power. Other paintings show how the railroad and telegraph brought change to society, with the tracks and wires of progress stretching ever in the distance. These cultural artifacts were also influenced by political ideas and proclamations.[6]

The idea of Manifest Destiny was politicized in 1845 when a democratic leader and influential editor by the name of John L. O'Sullivan gave the movement its name. In an attempt to explain America's thirst for expansion, and to present a defense for America's claim to new territories he wrote: ".... the right of our manifest destiny to over spread and to possess the whole of the continent which Providence has given us for the development of the great experiment of liberty and federaltive development of self government entrusted to us. It is right such as that of the tree to the space of air and the earth suitable for the full expansion of its principle and destiny of growth."[7] Manifest Destiny became the rallying cry throughout America. The notion of Manifest Destiny was publicized in the papers and was advertised and argued by politicians throughout the nation. It became the torch that lit the way for American expansion.

During the twentieth century, the success of the Industrial Revolution created the mass production of the automobile, harnessing of electricity into American cities, and development of telephone communications, which personally empowered every hard working American family that had the economic means to acquire and enjoy these new modern technologies. The Industrial

[6] Marx and Smith, 9.
[7] Alan Brinkley. *American History, A Survey*, Volume 1&2, 9th ed. (New York: McGraw-Hill, 1995), 352.

Revolution achieved a synergistic apex during the 1950's, combining successful manufacturing, improved national and international communications, and revolutions in transportation, which provided the means for America to achieve dramatic results, both economically and militarily. The generation of people that made these successes possible has been characterized as the *greatest generation* – people who had fought and won in two theaters of war and were ready to enjoy the fruits of their success. Americans and the western way of life was progress oriented, where the next piece of modern technology that could help them travel faster, run their appliances, and talk to whomever they wanted was the standard they lived by. Dr. Arnold Hutschnecker, a twentieth century psychiatrist, describes this about the nature of American culture: "Our American culture sets a high priority on achievement. The need to excel is a conditional process deeply ingrained in childhood. The philosophy of *making good* is evident as the driving force in a country that has coined the phrase *the sky's the limit*."[8] The fact that the American people could survive a revolutionary war, civil war, and two world wars in the process of achieving all of this progress is a testament to the power that technological development and American determinism can have on economics and society as a whole. Granted, the natural resources of the nation have been a major contributing factor to growth, but so has the ability to transform from an agrarian society, to an industrial society, to the current high-tech information age society.

The development of the computer, internet, and satellite communications are three of the latest technological advances that are driving change in the military and society as a whole. Digital technology has reduced the size and cost of computers to the point that hand-held devices are becoming required pieces of equipment, but the effort and investment required to achieve this level of technology has taken over 70 years to achieve. An engineer by the name of Vannevar Bush who graduated from the Massachusetts Institute of Technology (MIT) invented the first

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[8] Arnold A. Hutschnecker, *The Drive for Power* (New York: M. Evans and Company, Inc. 1974), 285.

analog computer in the late 1920's. It was the size of a large classroom and weighed several thousand pounds. His invention used mechanical devices to raise and lower levers, which could then be calibrated in such a way to solve mathematical equations. It was a crude machine, but it was the power of his ideas that initiated a completely new way to solve problems. The main idea that Bush had was what he called a "Memex" device. This device would someday sit on a desk and provide an extension of a person's brain, allowing information to be stored and later retrieved. Even though he did not ultimately invent digital technology, his ideas and leadership drove the process in the research and development field. The government was so impressed with his work that they hired him to lead the research and development effort during WWII, and he was eventually involved with the Manhattan Project that developed the atomic bomb.[9] As the Director of the Office of Scientific Research and Development, Dr. Vannevar Bush coordinated the activities of some six thousand leading American scientists in the application of science to warfare.

The interwar years between WWI and WWII had not been particularly productive for the research and development field due to the collapse of the stock market and isolationist policies of the government, but the Japanese attack on Pearl Harbor quickly changed this situation. President Roosevelt mobilized the whole nation for war and the industrial machine kicked into high gear. Science and technology made rapid advances in numerous fields, including aircraft, shipbuilding, radar, radio communications, and armored tanks. This rapid infusion of money and resources provided the foundation for government research using organizations like Defense Advanced Research Projects Agency (DARPA), as well as contracting the services of universities like MIT for research related activities. The combination of these efforts, as well as research from companies like Texas Instruments and INTEL, provided another form of collective synergy that laid the groundwork for the internet. The first version of the internet was called ARPANET, and

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[9] Vannevar Bush, "As We May Think", *The Atlantic Monthly*, July 1945. Accessed online at http://www.theatlantic.com/doc/194507/bush, 29 January 2006.

it linked the campuses of Stanford, UCLA, UC Santa Barbara, and the University of Utah with the mainframe computer in Massachusetts. Once the collaborative work had proven successful, the results were released and demonstrated to the public in 1972.[10]

From the time that Vannavar Bush wrote his paper describing the concept for a desktop computer in the early 1950's, it took 20 years to develop a rudimentary internet capability. It took another 20 years to fully develop the desktop computer and the internet, so that it was both affordable and useful to the public. The US is now in the third 20-year cycle where a true synergy of technological and organizational change is making an impact in the business world and the military. The business world has seen the value of technology and flattening their organizations, and the military is using this same idea to change their organizations in order to meet the needs of the global environment.

The primary point here is that technological innovation resulting in a revolution in military affairs takes time, money and research. Murray and Knox have it right in regards to this when they say, "If military revolutions are cataclysmic events that military institutions aspire merely to survive, revolutions in military affairs are periods of innovation in which armed forces develop novel concepts involving changes in doctrine, tactics, procedures, and technology. These concepts require time to work out. They involve extensive experimentation, which often results in failure. Their development also demands a culture that allows innovation and debate unfettered by dogma."[11] Indeed, it has been over 10 years since Desert Storm and the first large scale application of digital C4ISR technology, yet the concepts driving change in this realm continue to evolve under the Joint Vision 2020 construct.

Some military professionals are concerned about an over-abundance of emerging concepts, and think that the military is getting too far away from tried and true doctrinal methods

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[10] Internet Society, "A Brief History of the Internet", 10 December 2003. Accessed online at http://www.isoc.org/internet/history/brief.shtml, 11 February 2006.

[11] MacGregor Knox and Williamson Murray, *The Dynamics of Military Revolution* (New York: Cambridge University Press, 2001), 179-180.

of thinking and learning about waging war. A recent observation from LTG(R) Van Riper states, "For the past three years, I have watched with misgiving as the new Joint Capability Integration and Development System evolved into its current form. Unfortunately, I believe my apprehension has proved valid, for today JCIDS evidences all the signs of an overly bureaucratic and procedurally focused process. Moreover, in the last two years that process has led to the creation of an excess of concepts most of which-in my view-are devoid of meaningful content. My greatest concern is that as these concepts migrate into the curricula of professional military schools they will undermine a coherent body of doctrine creating confusion within the officer corps. In fact, I have begun to see signs of just that!"[12]

His concern about education is well founded, since there is a requirement for field grade officers to understand the fundamentals of operational art. There are also many competing agendas and concepts from all the respective services in regards to the new doctrine being generated, based on the technology being employed in today's armed forces. However, without an effective dialogue on concepts, learning does not occur, which can then result in a huge disconnect when developing new enabling technologies and systems. These disconnects can result in the failures in which Knox and Murray are referring. One example is the recent failure of the Navy and Army to agree on a new Unmanned Aerial Vehicle (UAV) platform, which may cost the government millions of dollars due to a breach of contract with the developer. Jim Wolf, Washington correspondent for Reuters news service, recently reported the following story regarding the UAV program:

"The U.S. Army likely will pay Lockheed Martin Corp. (LMT) tens of millions of dollars in contract termination fees for a botched attempt to produce a spy-plane meant to serve the needs of both the army and the navy, a senior army official said Monday. Bethesda, Maryland-based Lockheed Martin, the Pentagon's No. 1 supplier, was not at fault in the scrapping of the initial,

[12] LTG(R) Van Riper. "Concerns", *email to CJCS*, 11 December 2005. Forwarded from SAMS Information Technology Coordinator, 10 January 2006. Available on request from author.

$879 million contract announced Thursday, said Edward Bair, the army's program executive officer for electronic warfare and sensors. The total estimated production value of the program had been $8 billion, with the army expected to buy 38 aircraft and the navy, 19. The army killed the deal because problems with the aircraft, the Aerial Common Sensor, were too pricey to fix. This set the stage for Lockheed to negotiate a settlement. Bair said the armed services failed to think through whether a single aircraft could meet the separate needs of both services for communications-gathering, surveillance and reconnaissance."[13]

This is just one example of the challenges encompassing transformation initiatives, especially when developing new concepts and translating them into relevant solutions that meet the needs of the warfighter. LTG Van Riper may indeed be correct in his analysis of too many concepts creating confusion in the military. Moreover, if these concepts are not properly formulated and linked with the development of technology, then costly mistakes may continue to happen. There have been many other success stories concerning innovative technology, which will be covered in the next few chapters, but this previous example shows how difficult the management of complex digital C4ISR systems can prove to be for both the military and the businesses that are developing the technology. This also shows the importance of understanding the theories of Management of Technology (MOT) and Organizational Behavior (OB),[14] as digital technology improves, and as organizations in the military adapt to change.

The military is not just a muddy boots and mechanistic organization anymore that can rely on brute strength, mass, and powerful weaponry to solve its problems. The challenges and threats are not just oriented towards one or two regions of the world, but are global in nature and

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[13] Jim Wolf, "Lockheed to get U.S. spy-plane scrapping fees", *Reuters*, 16 January 2005. Accessed online at http://finance.myway.com/jsp/nw/nwdt_rt_top.jsp?cat=TOPBIZ&feed=bus&src=202&section=news&news_id=bus-n16141591&date=20060116&alias=/alias/money/cm/nw 16 January 2006.

[14] Management of Technology (MOT) can be defined as the planning, development and implementation of technological capabilities for the purpose of attaining the strategic and operational goals of organizations. Organizational Behavior (OB) is a field of study that looks at the impact individuals, groups and structures has on the behavior of people within an organization, for the purpose of using the results towards improving an organization's effectiveness.

include both conventional and unconventional threats. The idea that technology must be embraced in order to remain competitive in the world is explained by Thomas Friedman in *The World is Flat*. His theory basically says that the playing field has been leveled with the new technology that is prevalent today, allowing relatively new industrialized nations to compete on the global market like never before. Countries like China and India are becoming global competitors as well as partners in this new global economy. Russia's economy is also growing as they continue to modernize, and with vast natural resources in their favor, they will continue to compete in the global economy.[15]

Countries that want to take advantage of these changes in an aggressive manner may find themselves in extremely bad positions. For example, Iran has recently decided to continue the development of civilian nuclear energy, with the potential for producing nuclear weapons. The international community, particularly the European Union and the US, believe this poses a real threat to international security. Iran also plans to open their own securities exchange, called a bourse, which will allow them to trade oil in Euros rather than US dollars. And since Iran has their own satellite capability now, they plan to conduct these oil transactions using the internet, so that oil can be purchased by any country in a non-US currency. Some financial analysts predict that if this occurs, countries holding the US dollar in their reserves could begin to diversify into Euros sending the value of the dollar into rapid decline. The nature of this threat is likely to affect not only the United States, but also world markets as a whole. Instead of a global nuclear war, the world may be facing the more imminent threat of global economic war.

Samuel Huntington's Book *The Clash of Civilizations* attempts to shed some light on current conflict in the world when he describes how world politics is being reconfigured along cultural and civilizational lines. "In this world the most pervasive, important and dangerous conflicts will not be between social classes, rich and poor, or other economically defined groups,

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[15] Thomas L. Friedman, *The World is Flat: A Brief History of the Twenty-first Century* (New York: Farrar, Straus and Giroux, 2005).

but between peoples belonging to different cultural entities."[16] This may explain why Middle Eastern countries like Iraq, Iran, and Syria “clash” with the west, in that they may be doing what they think is necessary to preserve their culture and civilization from western influences.

Looking beyond ideological or cultural differences, it is also becoming a more dangerous world as nations compete for energy. The consumption of carbon-based resources also seems to be increasingly destructive to the global environment. Many more scientists are starting to realize that the world is a fragile place and that the ozone layer is the only thing protecting the earth from deadly ultra-violent rays. Some scientists are actually calling the earth a living, breathing entity that will not allow itself to be destroyed by man’s destructive activities. If this theory is true, then civilizations may need to decide to stop clashing and competing for resources that are destroying the earth. They may want to start getting serious about developing new technologies that do not rely on oil, and instead pursue clean and renewable energy that does not destroy the ozone layer. President Bush recently stated in his 2006 State of the Union Address that “the US is addicted to foreign oil”, and proposed an initiative to pursue new technologies that will break the cycle of reliance on foreign oil.[17] This important initiative will help in some degree, however, some of the critical commentary following the speech also made the point that every president since Richard Nixon has said the same thing. The fact is that the US is an oil-based economy, and until a transformation in energy occurs, the US and every other nation competing in the world will aggressively pursue this resource. Also, if the underlying and predominate motives in the US are profit and accumulation of wealth, and the pursuit of global-economic advantage is perceived as too aggressive, then conflict with other nations will occur.

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[16] Samuel Huntington, *The Clash of Civilizations and the Remaking of World Order* (New York: Touchstone, 1996), 28.

[17] Office of the Press Secretary, *State of the Union: The Advanced Energy Initiative* (Washington D.C.: White House, 31 January 2006). Accessed online at http://www.whitehouse.gov/news/releases/2006/01/20060131-6.html 17 February 2006.

Greek literature in both the Homeric and Platonic tradition warns political and military leaders of the state to guard against the temptations of *hubris* and *fortune*. This is the tendency for man to become obsessed with the desire for power, and all the wealth and glory that can be obtained in this quest. The ancient Greeks believed that these temptations should be tempered with the idea of *virtue*, and the necessity of living a life of high moral and ethical fiber that served society as a whole. Athens eventually succumbed to the temptations of hubris and fortune when they attempted to accumulate too much wealth and power. Other city-states in the Delian League rose up in defiance against Athens and put a stop this over-extension of power, which ultimately can be attributed to a desire for too much *fortune* caused by *hubris*.

John Ickenberry, Professor of Geopolitics and Global Justice at Georgetown University, addresses the fundamental issues of global politics--who commands and who benefits--and the use of military force. He describes the current debate among scholars such as Michael Mann: *Incoherent Empire*, and Benjamin Barber: *Fear's Empire*. "Mann and Barber both make the important point that an empire built on military domination alone will not succeed. In their characterization, the United States offers security -- acting as a global leviathan to control the problems of a Hobbesian world -- in exchange for other countries' acquiescence. Washington, in this imperial vision, refuses to play by the same rules as other governments and maintains that this is the price the world must pay for security. But this U.S.-imposed order cannot last. Barber points out that the United States has so much "business" with the rest of the world that it cannot rule the system without complex arrangements of cooperation.[18] Mann, for his part, argues that military "shock and awe" merely increases resistance; and cites the sociologist Talcott Parsons, who long ago noted that raw power, unlike consensus authority, is "deflationary": the more it is used, the more rapidly it diminishes.[19],[20]

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[18] Benjamin R. Barber, *Fear's Empire: War, Terrorism and Democracy* (New York: Norton, 2003).

[19] Michael Mann, *Incoherant Empire* (New York: Verso, 2003).

It is therefore critical to world security, especially when considering competition for nuclear power and oil, that the United States not be too hasty in using the threat of force. Certainly, the promotion of world trade and globalization has to allow for the possibility that a system based on US hegemony and one currency exchange in energy resources may not be the correct system anymore. The world may need a two-currency system (US dollar and Euro) or a multi-currency system that recognizes other significant players in the world, and that reduces the temptation for one country to pursue its interests, while minimalizing the interests of others.

This chapter has described the idea of technology synergy theory as an agent of change. It has attempted to provide insight as to how society, culture, resources and threats impact the pursuit of innovation through technology, and how adaptive changing organizations occur simultaneously rather than one causing the other. Examples were provided in order to gain a better understanding of how digital technology is impacting the military and the world as a whole. The ability to think globally is more important now than at any other time in the history of the US military and government. The decisions that our political leaders make will determine the path that our country will take in the future, and the actions that the military takes will clearly make a global impact like no other time in the past. As a global leader, the United States must use its technological power in the most responsible manner possible, while relying on human ingenuity and engagement across all aspects of the diplomatic, informational, and economic equation to meet the challenges of the twenty first century.

[20] G. John Ickenberry, "Illusions of Empire: Defining the New American Order", *Foreign Affairs*, March/April 2004. Accessed online at www.foreignaffairs.org 26 January 2006.

CHAPTER THREE

CURRENT C4ISR CAPABILITIES

Military operations in the GWOT have been both successful and challenging. They have been successful due in large part because the United States has maintained its status as the world's most technologically advanced superpower, with the responsibility of defending the nation and its allies against both conventional and asymmetric threats. Recent operations have been challenging, because joint forces continue to develop and implement force transformation initiatives under the Joint Vision 2020 concept, while operating with a smaller all-volunteer force requiring a significant contribution from the National Guard and Reserves. From a strategic perspective, the shocking events of 9/11 also signified a turning point in national security policy from one of engagement and deterrence to a policy of pre-emption, which meant that the military would now be conducting more pro-active operations to respond to the threat of terrorism and rogue states, while also continuing the transformation to a network-centric force. One analogy that has been used is that the military is attempting to rebuild a large aircraft while in flight. A recent study implemented by the Department of Defense and authored by Andrew Krepenivich states that the Army is overly stretched, and even characterized them in terms of "A thin green line". Secretary Rumsfield refuses to believe that the Army may be at a breaking point, and said, "Today's Army is the most capable, best-trained, best-equipped and most experienced force our nation has fielded in well over a decade".[21]

Both viewpoints have their merit, however, the fact remains that the US now has to respond to a full range of global threats and responsibilities, while simultaneously transforming the force, and also relying heavily on part-time military forces. Considering the nature of this situation, and the pervasive American philosophy that innovation through technology is a large

[21] Associated Press. "Report: Army could be near breaking point", *MSNBC*, 24 January, 2006. Accessed online at http://www.msnbc.msn.com/id/11009829/ 25 January 2006.

part of the equation, it is no surprise that enabling the warfighter through technology continues to be a major focus of the GWOT. This chapter will explain current C4ISR capabilities that are being used in the categories of space, aerial, and ground-based systems. Before looking at some of the technological tools of the trade, it is important that one understands a theory that supports the implementation of space-based capabilities, the primary enabler for the network-centric force.

Space-based capabilities, also known as space force enhancement, are the critical enablers that provide the transfer of digital information between the Continental United States (CONUS), Regional Combatant Commanders, and Joint Forces in theater. The US currently maintains a commanding presence in space-based capabilities, which must be maintained if the network-centric operations concept is going to remain valid in the future. One of the theorists who can help explain why the command of space is key to joint force success is Julian Corbett, a rather obscure British naval military theorist. His main thesis was that the nation that secured lines of communications on the sea will command the sea.[22] This is Corbett's enduring legacy to the conduct of modern warfare, and a theory that can also be applied to the command of space. Using Corbett's model, the command of space is accomplished by securing lines of communications through security at home, strategic dispersion of assets in space, and the concentration of space assets and capabilities when necessary to defeat a belligerent force.[23]

Corbett did not embrace the idea of massing naval forces in order to command the sea. Instead, he took the broader view of maintaining maritime supremacy, which included the security of homeports, trade routes and strategic locations, as well as freedom to govern through open lines of communication across the British Empire. When translating this to command of space, the first requirement for the United States is maintaining security at the ground stations

[22] Julian S. Corbett, *Some Principles of Maritime Strategy* (Annapolis, MD: Naval Institute Press, 1988).

[23] John J. Klein, "Corbett in Orbit: A Maritime Model for Strategic Space Theory", *Naval War College Review*, Winter 2004.

controlling satellites and the ability to launch new satellites. Without security at home, the US cannot maintain its space based superiority.

Using Corbett's model for strategic dispersion of naval forces, in order to maintain lines of communications with the strategic employment of space assets means positioning satellites to provide critical capabilities such as Global Positioning System (GPS), Military Satellite Communications (MILSATCOM), and the ability to collect intelligence as required by the National Command Authority, SECDEF, and Joint Service Chiefs. These capabilities are used by Joint Forces around the globe to conduct rapid operations within the enemy's decision cycle. In addition, since naval forces cannot provide coverage of every sea-lane due to the size of the sea, space forces cannot provide 100% coverage of the earth due to the size of space. The best course of action strategically is to provide coverage at the critical areas around the globe that can maximize the use of space force assets.

Also, there are times when space force capabilities must be massed at the critical place and time, in order to achieve dominance over a particular region of the world. In order to achieve critical effects from space, assets must be tasked accordingly from the Joint Force Commander. Especially when time is a factor (i.e. time sensitive targets), command and control through secure lines of space communications is what gives the United States the advantage and allows ground, air, and sea forces to mass effects at the critical time and place to defeat the enemy. This is what Corbett was referring to when he said it was possible to operate in a strategically dispersed manner on the sea, deceiving the enemy as to friendly forces plans, denying certain areas of the sea, and massing forces at the right time and place with an offensive strike that the enemy does not expect. The same principle is true for space, and must be accomplished to maintain space force dominance. Satellite systems, combined with air, sea, and land C4ISR systems, provide the capabilities that are required for joint forces operating in places like Afghanistan and Iraq.

Space-Based Systems

According to General Tommy Franks, the US had flown an average of 200 sorties per day in Afghanistan by early February 2002, which is significantly less than the sortie rate in Operation Desert Storm of 3,000 per day. In Afghanistan, the US was, however, able to hit roughly the same number of targets per day as in Desert Storm. General Franks also stated that "while the US needed an average of ten aircraft to take out a target in Desert Storm, a single aircraft could often take out two targets during the fighting in Afghanistan."[24] The advances in satellite GPS, reconnaissance, weather, and communications systems have made these types of operational results possible.

By looking at some of the key space systems, moving down to the aerial systems, and finally looking at the ground systems, one can begin to appreciate the complexity of C4ISR architectures. These enabling technologies are what provide US forces and their leaders the means to achieve unparalleled advantages in both current and future operations. They allow forces to be employed at the right time and the right place in order to meet the objectives set forth by the national command authority. They also allow joint force commanders and operational planners with the means to develop contingency plans that address the threats within their areas of responsibility. As new threats to national security emerge, C4ISR assets should be tasked and organized in order to prepare for future joint service requirements. The next few sections will provide a basic understanding of the technological systems that empower the joint force, the industry partners responsible for bringing solutions to the warfighter, and how the research and development experts contribute to the process.

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[24] Anthony H. Cordesman, *The Ongoing Lessons of Afghanistan* (Washington D.C.: Center for Strategic and International Studies, 6 May 2004), 37.

The Global Positioning System: NAVSTAR Constellation

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Figure 1: NAVSTAR GPS Satellite

Photo: Boeing. Online @ www.mdc.com/defense-space/space/gps/m_gen.html

The NAVSTAR Global Positioning System (GPS) is the constellation of satellites used by joint forces to enable the improved effectiveness in target acquisition and navigation. The latest version being fielded is the block IIF, which is manufactured by Boeing and will consist of 33 satellites. NAVSTAR (Navigation System using Timing and Ranging) provides latitude, longitude, altitude, direction of travel, travel velocity, and correct time of day to joint forces at any time and any weather condition. Combine this with the Internal Navigation System (INS) of precision guided munitions, and this technology is what enabled highly accurate effectiveness in acquiring targets during OIF and OEF. These operations included the use of immensely successful GPS guided munitions, such as JDAM (Joint Direct Attack Munition), allowing pinpoint accuracy with minimum collateral damage.[25]

[25] Boeing, "GPS IIF/III", *Boeing Integrated Defense Systems*, February 2006. Accessed online at www.mdc.com/defense-space/space/gps/m_gen.html 17 February 2006.

The ability to link joint forces during OEF and OIF with enhanced C4ISR systems provided improved command and control, intelligence, targeting, precision strike, assessment, and re-strike capabilities. Increased effectiveness was achieved by collecting real-time imagery and electronic intelligence data depicting ground forces using satellites, U-2s, E-8 JSTARS, RC-135 Rivet Joint, E-3A AWACS, E-2s, P-3s, and UAVs (Global Hawk and Predator). These combined collection efforts provided the capability to cover and characterize fixed targets, and also target mobile enemy forces with high precision in real time using these systems. Improvements in digital technology, sensors, moving target radars, and synthetic aperture radars also reduced problems associated with weather and cloud cover. US forces had the technical ability to communicate this data, which included the precise GPS targeting data for US bombers and strike fighters, sea-launched cruise missile platforms, and special operations soldiers. This allowed aircraft like the F-16, F-15, AC-130, F-18, B-1, and B-52, and B-2 to retarget in flight, and also conduct re-strike missions after damage assessment using SOF, airborne, and space-based assets.

One of the most vivid examples of how technology can transform the application of military power is the SOF combat air controller who was photographed riding on horseback in Afghanistan. His method of moving around on the battlefield was as ancient as organized warfare itself. The fact that he could use a laptop, GPS, satellite radio, and laser designator to call in air strikes and place a 2000 pound JDAM with pinpoint accuracy on the target is a testament to how technology has empowered and enabled forces on the ground. Take that example and transform it into the Brigade Combat Team (BCT) that has been "digitized" and empowered with everything from SATCOM, Blue Force Tracker, UAVs, and every other C4ISR asset in the joint force and you have a capability that is unmatched on virtually any battlefield of the future. The BCT is only as restricted as the logistics required to sustain it.

General John Abizaid, CENTCOM Commander, had this to say about joint C4ISR systems in his statement to the House Armed Services Committee: "Intelligence-surveillance-

reconnaissance (ISR) systems, especially unmanned aerial vehicles (UAVs), are a key part of the Joint warfighting team. All the Services contribute to this diverse array of systems and all benefit from the integrated intelligence products they produce. Another success has been joint command and control across a region where we simultaneously conduct large-scale ground combat, precision counter-terrorist operations, maritime interdiction operations and full-spectrum air support."

He went on to describe the challenges that joint forces still face in regards to these systems by stating, "Command and control (C2) systems are still developed and maintained by the Services and are not easily integrated for Joint operations. We need C2 systems that not only enable but enhance the capabilities of Marine aircraft flying from a Navy carrier under the command and control of an Air Force headquarters in close support of Army troops or Special Forces on the ground. Today our systems are mostly patched together, often with great effort and resulting in sub-optimal performance. The whole is less than the sum of the parts. To reverse this situation, we must field systems purpose-built for joint operations, so our superb joint forces are enabled rather than inhibited". This reinforces the point that transformation initiatives are making progress in the GWOT, but that there is still much more work to be done. The next section describes the military satellite communications (MILSATCOM) systems currently supporting joint operations.

DOD satellite communications systems include the Ultra High Frequency Follow-on (UHF F/O) satellite system, the Defense Satellite Communications System (DSCS) operating in the Super High Frequency (SHF) spectrum, and the Milstar System operating in the Extremely High Frequency (EHF) spectrum. These three systems provide the enabling technology that allows commanders to project forces worldwide to strategic locations, communicate in theater, and reach back to areas of sanctuary. Without these systems, joint forces would not be able to operate in austere environments, project forces into theater rapidly, or sustain the fight once in theater.

The MILSATCOM constellations: Milstar, DSCS, UHF F/O and FLTSATCOM

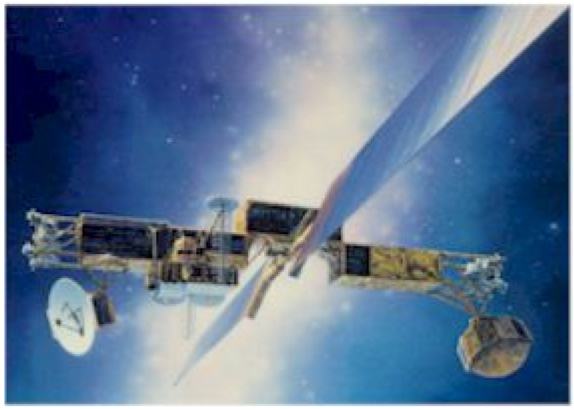

Figure 2-Milstar Satellite

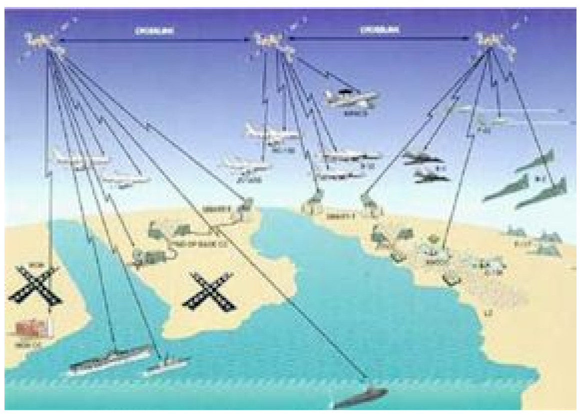

Figure 3-Milstar Concept

Photos: Lockheed Martin and Air Force. Online @http://spaceflightnow.com/titan/b35/030401milstar.html

The biggest improvement for military satellite communications (MILSATCOM) has been the Milstar satellite constellation. Lockheed Martin Space Systems is the prime contractor, TRW Space and Electronics Group provides the low data rate payload, and Boeing Satellite Systems provides the medium data rate payload. It operates in the Extremely High Frequency (EHF) and Super High Frequency (SHF) ranges and meets joint force requirements world wide with voice, data, and fax capabilities up to 1.5 megabytes/second. The combination of data rates and operational frequencies provides joint forces with much better capabilities than previous Defense

Satellite Communications System (DSCS) satellites. Improvements include anti-jamming, low probability of intercept and detection, and improved communication on the move. Milstar was designed to provide secure command and control capabilities for the National Command Authority, strategic, and other tactical forces. This constellation can communicate without ground station links, providing a switching capability in space between satellites, thus reducing risk and providing rapid and secure communications as required by joint forces.

Figure 4-DSCS Satellite

Photo: Lockheed Martin. Online @ www.spaceflightnow.com/delta/d300/

Defense Satellite Communications System (DSCS) satellites are the workhorse of the space-based communications architecture. Lockheed Martin is the prime contractor and the Air Force has the responsibility for operating 13 Phase III DSCS satellites. They are designed to provide SHF wideband communications for worldwide long haul communications to fixed stations and mobile critical national, strategic, tactical and other designated governmental users. This includes Presidential communications, the Worldwide Military Command and Control System (WWMCCS), from early warning sites to operations centers, and unified and specific commands and tactical forces. Each DSCS also has a single channel for broadcasting emergency action messages to nuclear forces.

Following the successful launch of the final DSCS satellite in April 2003, Major Dave Martinson, chief of MILSATCOM operations for Air Force Space Command said, "I can't stress how important it is for the nation to have that capability to have secure communications. We use these communications from the president of the United States all the way down to the solitary special operation troops in the field," He described the difference between Milstar and DSCS by adding, "We think of it as a small soda straw for Milstar and a big, gigantic hose for DSCS. In simple terms, when you have to get a lot of data through, DSCS is the way to do it".[26]

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Figure 5: UHF F/O Satellite and Phase II GBS Concept

Photo: Boeing. Online @ http://www.boeing.com/defense-space/space/bss/factsheets/601/gbs/gbs.html

The Global Broadcast System (GBS) is a capability that was installed on several Ultra-High Frequency Follow-on (UHF F/O) satellites to provide high data rate information for joint forces in worldwide theaters of operation. GBS uses commercial direct broadcast technology to provide end users with intelligence dissemination, wideband internet message traffic, mapping

[26] Lockheed Martin, " Milstar satellite overview", *Spaceflight Now*, 1 April 2003. Accessed online at http://www.spaceflightnow.com/delta/d300/ 5 February 2006.

and weather video, targeting information, logistics information, air tasking orders, and pre-mission planning information. Broadcast management centers in rear areas package the information, send it via GBS primary injection points to UFO satellites, and joint forces receive the information using 22-inch diameter mobile and affordable tactical terminals.

Overhead Reconnaissance and Signals Intelligence: National Security Agency (NSA), National Reconnaissance Office (NRO), and the National Geospatial Aerospace Agency (NGA)

Figure 6-Defense Support Program Satellite

Image: US Air Force Online @ http://www.spaceflightnow.com/titan/b31/010726dsp.html,

Figure 7-Communications Relay Satellite

Image: National Reconnaissance Office http://www.nro.gov/satpics.html

The National Security Agency (NSA), established in 1952 by President Truman, is responsible for the collection and dissemination of signals intelligence (SIGINT), as well as Information Assurance (IA) of all DOD and national intelligence agencies computer systems. The NSA's global electronic surveillance system is supported by satellites, ground stations, and highly efficient computers that can search for specific information related to national security. The National Reconnaissance Office (NRO) is responsible for developing and maintaining the satellites that support the system, and the NSA gathers the collected information using ground and processing stations. During congressional hearings for the 1996 Intelligence Authorization Act, one member of the session stated, "The NRO collects sensitive information better than

anyone else, anywhere else in the world. Let me repeat that: no one, anywhere—the Russians, the French, the Germans, the Japanese, even DOD—is better at this business than the NRO".[27]

The ability to provide Information Assurance (IA) of digital information systems has been critical in the GWOT. The NSA has provided teams to geographic combatant commanders in theater for the purpose of ensuring that intelligence support is provided as required by commanders, and so that the systems that process information are protected during operations.

The Defense Support Program (DSP) is an important part of the North American and Theater Ballistic Missile (TBM) detection systems. The primary mission of this system, under the direction of US Strategic Command (STRATCOM), is to detect, characterize, and report in real time missile and space launches occurring in the satellites field of view. These satellites track missiles by observing infrared (IR) radiation emitted by the rocket's exhaust plume. The IR telescope uses photoelectric cells, which detects and measures the IR energy given off by hot sources on the earth. Sensors are also onboard the satellite that detect and quantify nuclear explosions. During Desert Storm these systems were able to detect scud missiles launched in Iraq towards Israel and Saudi Arabia. DSP satellites have been around for over 30 years and will be replaced soon with new space radar systems. The latest improvement to the program is the Mission Control Station (MCS) located at Buckley AFB, CO, which consolidates C2 and data processing elements from dispersed legacy systems into one modern facility.

The National Geospatial-Intelligence Agency (NGA) is responsible for providing timely, relevant, and accurate geospatial intelligence (GEOINT) in support of national security objectives. GEOINT is the exploitation and analysis of imagery and geospatial information to describe, assess, and visually depict physical features and geographically referenced activities on the Earth. Information collected and processed by NGA is tailored for customer-specific

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[27] Congressional Record, *Intelligence Authorization Act of Fiscal Year 1996* (Wahington D.C.: US Senate, 29 September 1995). Accessed online at http://www.fas.org/irp/congress/1995_cr/sen29sep.htm 24 February 2006.

solutions. By giving customers ready access to GEOINT, NGA provides support to civilian and military leaders and contributes to the state of readiness of U.S. military forces. NGA also contributes to humanitarian efforts such as tracking floods and fires, and in peacekeeping.[28] One of the major improvements that the NGA is implementing is called Community On-Line Intelligence System for End-Users and Managers (COLISEUM), which will eventually provide any authorized person with a PC access to imagery products in support of joint operations.[29] The NGA uses satellite data from the NRO and other sources in support of the intelligence community in order to understand enemy activity, plan attack strategies, support ground reconnaissance, find enemy sites producing nuclear, chemical and biological weapons, monitor the flanks of deployed troops, watch for shoreline threats to sea lanes, look out for terrorists attack, and to locate the sources of intercepted signals.

The current debate on the national terrorist surveillance program is capturing the attention of the media around the world, and particularly in America, where there is a concern that freedom under the Fourth Amendment may be violated with the program. This is really nothing new, since the capability to gather intelligence through wiretap authorization has been questioned and debated in congress for the past several decades. With the advances in telecommunications technology proliferating around the world, there will be an even greater need to keep these systems funded and updated with the most advanced capabilities available, so that the US can maintain it's technological edge and prevent another 9/11 type catastrophe.

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[28] The National Geospatial-Intelligence Agency, Factsheet, February 2006. Accessed online at http://www.nga.mil/portal/site/nga01/index.jsp?epi-content=GENERIC&itemID=31486591e1b3af00VgnVCMServer23727a95RCRD&beanID=1629630080&viewID=Article 28 February 2006.

[29] Space Operations Office, *US Army Space Reference Text* (Fort Leavenworth, KS: Command and General Staff College, December 2004).

Manned and Unmanned Aerial Systems: Predator, Global Hawk, AWACS, JSTARS, Rivet Joint

Figure 8-RQ-1A Predator

Figure 9-Global Hawk

Photos: Air Force. Online @ www.af.mil/factsheets/factsheet.asp?fsID=175

Perhaps the most innovative and sought after C4ISR technologies being employed in the GWOT are the Predator and Global Hawk UAVs. The RQ-1A, Predator UAV is manufactured by General Atomics in San Diego, California. Each Predator system is composed of four UAVs, a ground control station, a satellite communications terminal, and 55 personnel. This system was first used during the Bosnia campaign in 1995, in Afghanistan in 2002, and was officially considered operational in 2004. The Predator is equipped with reconnaissance equipment and weapons to provide persistent ISR capabilities. Unlike many other UAVs, Predator has target engagement capability on-board, employing Hellfire missiles. The armed version is designated

MQ-1. As a multi-sensor platform, Predator is equipped with electro-optical/infrared (EO/IR) and synthetic aperture radar (SAR) payloads. The UAV uses line of sight communications data link or satellite communications, to receive flight instructions and transmit video streams, still images and other sensor information to the mission control center. Information gathered by a Predator can be shared instantaneously with commanders around the world via remote receiving stations. Imagery products are distributed worldwide via defense communications satellites or commercial services, utilizing the Trojan Spirit II intelligence distribution satellite terminals and Distributed Common Ground System (DCGS) intelligence support network.[30]

In his March 11, 2004 testimony before congress, General Moseley, Vice Chief of Staff of the Air Force stated, "OIF was the Predator's first *networked* operation. Four simultaneous Predator orbits were flown over Iraq and an additional orbit operated over Afghanistan, with three of those orbits controlled via remote operations in the US. This combined reachback enabled dynamic support to numerous OIF missions. Predator also contributed to our operational flexibility, accomplishing hunter-killer missions, tactical ballistic missile search, force protection, focused intelligence collection, air strike control, and special operations support. A Hellfire equipped Predator also conducted numerous precision strikes against Iraqi targets, and flew armed escort missions with US Army helicopters."[31]

Global Hawk is a new UAV system manufactured by several companies, with Northrop Grumman in San Diego as the prime contractor. The program is funded by the Defense Airborne Reconnaissance Office (DARO) and managed by the Defense Advanced Research Projects Agency (DARPA) and the US Air Force. This new system provides commander's near-real-time,

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[30] General Atomics/USA, "RQ-1A/MQ-1 Predator", Defense Update: International Online Defense Magazine, 2005, Issue 2. Accessed online at http://www.defense-update.com/products/p/predator.htm 1 February 2006.

[31] General T. Michael Moseley, *Congressional Testimony on the Adequacy of the Fiscal Year 2005 Budget to meet Readiness Needs* (Washington D.C.: House Armed Services Committee, March 11, 2004). Accessed online at http://www.house.gov/hasc/openingstatementsandpressreleases/108thcongress/04-03-11moseley.html 3 February 2006.

high-resolution, intelligence, surveillance and reconnaissance imagery. In the last year, the Global Hawk provided Air Force and joint warfighting commanders more than 15,000 images to support Operation Enduring Freedom, flying more than 50 missions and 1,000 combat hours to date. Cruising at extremely high altitudes, Global Hawk can survey large geographic areas with pinpoint accuracy, to give military decision-makers the most current information about enemy location, resources and personnel. Once mission parameters are programmed into Global Hawk, the UAV can autonomously taxi, take off, fly, remain on station capturing imagery, return and land. Ground-based operators monitor UAV health and status, and can change navigation and sensor plans during flight as necessary.32

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Figure 10-AWACS Aircraft

Photo: Air Force. Online @ www.boeing.com/companyoffices/gallery/images/infoelect/awacs.html

The E-3 Airborne Warning and Control System (AWACS) represents the world's standard for airborne early warning systems. E-3 fills the needs of both airborne surveillance and command and control (C2) functions for tactical and air defense forces. It provides a highly mobile, survivable surveillance and C2 platform with superior surveillance capabilities. It is equipped with ”look-down" radar that can separate airborne targets from the ground and sea

[32] US Air Force, “Global Hawk”, *Air Force Link*, February 2006. Accessed online at http://www.af.mil/factsheets/factsheet.asp?fsID=175 12 February 2006.

clutter return signals that confuse other present-day radars. Its radar "eye" has a 360-degree view of the horizon, and at operating altitudes can "see" more than 320 kilometers (200 miles). It also can detect and track both air and sea targets simultaneously. In service since 1977, AWACS has earned the reputation as an international keeper of the peace in operation with the U.S. Air Force, NATO, United Kingdom, France and Saudi Arabia.[33] Without this airborne surveillance and communication system, joint and coalition operations in the GWOT would not achieve the air superiority and airspace dominance that is required for successful operations.

Figure 11-JSTARS Aircraft

Photo: Air Force. Online @ www.airforce-technology.com/projects/jstars/jstars3.html

The Joint Surveillance and Target Attack Radar System (JSTARS) is a joint development project of the US Air Force and Army which provides an airborne, stand-off range, surveillance and target acquisition radar and command and control centre. In September 1996, JSTARS was approved for full rate production for 14 aircraft, the last of which was delivered in August 2002. Three further aircraft were delivered between February 2003 and March 2005. The 116th Air Control Wing operates the JSTARS aircraft at Robins Air Force Base in Georgia. The 116th is a "blended wing" with both Air Force and Air National Guard personnel. JSTARS provides ground situation information through communication via secure data links with air force

[33] Boeing, "E-3 AWACS", *Boeing Link*, February 2006. Accessed online at http://www.boeing.com/defense-space/infoelect/e3awacs/ 17 February 2006.

command posts, army mobile ground stations and centers of military analysis far from the point of conflict. JSTARS provides a picture of the ground situation equivalent to that of the air situation provided by AWACS. JSTARS is capable of determining the direction, speed and patterns of military activity of ground vehicles and helicopters. JSTARS was first deployed in Operation Desert Storm in 1991 when still in development, and has since been deployed to support peacekeeping operations in Bosnia-Herzegovina and during the Kosovo crisis. Eight JSTARS aircraft flew more than 50 missions in support of Operation Iraqi Freedom in March/April 2003.[34]

Figure 12-RC-135V/W "Rivet Joint" Aircraft

Photo: FAS Intel Resource Program. Online @ www.fas.org/irp/program/collect/rivet_joint.htm

The RC-135V/W Rivet Joint reconnaissance aircraft supports theater and national level consumers with near real time on-scene intelligence collection, analysis and dissemination capabilities. Modifications on this C-135 platform are primarily related to its on-board sensor suite, which allows the mission crew to detect, identify and geo-locate signals throughout the electromagnetic spectrum. The mission crew can then forward gathered information in a variety of formats to a wide range of consumers via Rivet Joint's extensive communications suite. The

[34] US Air Force, "JSTARS", a*irforce-technology*, February 2006. Accessed online at http://www.airforce-technology.com/projects/jstars/ 17 February 2006.

interior seats 34 people, including the cockpit crew, electronic warfare officers, intelligence operators and in-flight maintenance technicians. The Rivet Joint fleet is currently undergoing significant airframe, navigational and powerplant upgrades, which include flight deck instrumentation and navigational systems to the AMP standard. The AMP standard includes conversion from analog readouts to a digital "glass cockpit" configuration.

All Rivet Joint airframe and mission systems modifications are overseen by L-3 Communications (previously Raytheon), under the oversight of the Air Force Materiel Command. The current RC-135 fleet is the latest iteration of modifications to this pool of –135 aircraft going back to 1962. Initially employed by Strategic Air Command to satisfy nationally tasked intelligence collection requirements, the RC-135 fleet has also participated in every sizable armed conflict involving U.S. assets during its tenure. RC-135s have maintained a constant presence in Southwest Asia since the early 1990s.[35]

Figure 13-P-3 "Orion" Aircraft

Photo: FAS Military Analysis Network. Online @ http://ftp.fas.org/man/dod-101/sys/ac/p-3.htm

Both the US and Britain have realized the possibilities of improved ISR technology from Afghanistan, where permissive air environments, new sensor and targeting systems, and long-

[35] US Air Force, "RC-135 V/W Rivet Joint", *Air Force Link*, February 2006. Accessed online at http://www.af.mil/factsheets/factsheet.asp?fsID=121 24 February 2006.

range precision strike systems allowed older, long-range slow fliers like the P-3 and British Nimrod, to be armed and used as delivery platforms. New upgrades in digital technology could even allow tankers and transport aircraft to be reconfigured for use in strike roles. The P-3, for example, was designed for maritime surveillance and antisubmarine warfare missions, but was used as a land-based observation plane by the SEALs. The P-3 possessed data links to the Predator and E-8 JSTARS, and provided real time reconnaissance during Operation Anaconda and the fighting in the Shah-i-Kot Valley.

OEF also demonstrated how the nature of war from a command and control perspective has changed. Joint headquarters are becoming more proficient at planning and executing at the strategic and operational levels from thousands of miles away using the power of technology. CENTCOM was able to manage the fight largely from Tampa, Florida, and the Combined Air Operations Center (CAOC) conducted their planning and issued the Air Tasking Order (ATO) from Bahrain. Once General Franks briefed the President on the plan on 2 October 2001, the initial phase of OEF was initiated on 7 October, and the capitol of Kabul was liberated from Taliban and Al-Qaeda forces by 13 November, two days before the Combined Forces Land Component Command (CFLCC) assumed control of land operations. By 22 December, Hamid Karzai had been sworn-in as Prime Minister of the interim government of Afghanistan, and the International Security Assistance Force (ISAF) was established in Kabul.

The effectiveness of joint forces during OEF have shown the value of integrating land, sea, and air operations in an adaptive manner that meet the needs of the situation. It has shown how the combination of precision strike capabilities using the enabling power of C4ISR technology can, in some instances, provide much of the heavy firepower that was previously required by a large ground force using artillery and armor. The statistics show that approximately 60% of the air strike weapons used in Afghanistan by June of 2002 were precision equipped, allowing an estimated accuracy rate of 90%. This can be attributed to improvements in C4ISR technology and tactics, techniques, and procedures from the previous 12 years.

Ground Systems: Grenadier BRAT, FBCB2, UTAMS, PSDS2

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Figure 14-Grenadier BRAT

Photo: Boeing. Online @ www.boeing.com/defense-space/ic/grenbrat/index.html

Figure 15-FBCB2

Photo: Northrop Grumman. Online @ www.ms.northropgrumman.com/markets/MDFbcb2.html

Achieving real-time or near real-time situational awareness using a Common Operational Picture (COP) is one of the key tenets of network-centric warfare, and was probably the most significant contribution technology-wise for joint force commanders during OEF and OIF. This capability, combined with precision strike and a robust C4ISR architecture, facilitated the rapid advance towards Baghdad. The Boeing Company Grenadier Beyond Line-of-Sight Reporting and Tracking (BRAT) system is a blue-force tracking tool being fielded by Space and Missile Defense Command's Army Space Program Office (ASPO), which is designed to provide the utmost in operational and deployment flexibility. The Grenadier BRAT (GB) system enables

commanders to track and locate multiple assets in near-real time anywhere in the battlespace, even when line-of-sight communications with those forces are not possible, and allows for expansion into future communications platforms. GB works by first calculating position information through the signal it receives from GPS satellites. After the location has been determined, GB transmits this data along with unit identification and a brevity code via a special waveform. The waveform has a very low probability of intercept and low probability of detection. GB uses existing collection and dissemination architectures to provide its data to the commander. Blue-force tracking data can be received and processed with the Army Tactical Exploitation of National Capabilities (TENCAP) equipment and displayed as standard military symbols. The Boeing GB system is optimized to increase combat effectiveness by providing the best and most comprehensive solution to the blue-force tracking requirement.[36]

The Force XXI Battle Command, Brigade-and-Below (FBCB2) provides situational awareness and C2 to the lowest tactical level. It is designed by Northrop Grumman for the Army to provide a seamless flow of battle command information across the battle space, and it is also interoperable with external C2 and sensor systems, such as the Army Battle Command System (ABCS). FBCB2 provides a common database with automated friendly positional information. It also provides current tactical battlefield geometry for friendly forces as well as for known or suspected enemy forces. Collectively, the FBCB2 systems generate the friendly operating picture. It displays relevant information, showing the user his location, the location of other friendly forces, observed or templated enemy locations, and all known obstacles. It also provides preformatted, standardized reports, allowing leaders to disseminate graphic overlays and written OPORDs and FRAGOs rapidly. The warfighter receives data "pushed" from all other battlefield systems to maintain real-time battle information. These battlefield systems draw upon the reports and positional data passed on from the lower tactical internet (TI) to provide information at

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[36] Boeing, "Grenadier BRAT", *Boeing Integrated Defense Systems*, February 2006. Accessed online at http://www.boeing.com/defense-space/ic/grenbrat/index.html 24 February 2006.

higher command levels. They push information such as location of adjacent units, known and templated enemy positions, graphics, and OPORDs down to the FBCB2 users.[37]

Figure 16-UTAMS Sensor Array (on top of tower)

Photo: RDECOM. Online @ http://www.rdecom.army.mil/rdemagazine/200506/part_agi.html

The Unattended Transient Acoustic MASINT System (UTAMS) is an Army Research Labs (ARL) initiative that was developed in an extremely short time period for US forces in Iraq and Afghanistan. It also won the US Army Research, Development, and Engineering Command (RDECOM) top ten new inventions of the year award for technology, primarily because it was fielded in only three months from the time the request was submitted. The system uses new digital technology combined with an old concept (sound ranging using microphones), and the unit cost per system is only $150,000. The system uses measures and signals intelligence (MASINT) technology to measure sound waves using sensors placed at four different locations. A computer processing unit (CPU) is connected to the sensor tripod, and a temperature sensor is linked-in to account for environmental effects on how sound waves travel in hot or cold weather. Radio

[37] "Force XXI Battle Command, Brigade and Below (FBCB2)", *Global Security*, February 2006. Accessed online at http://www.globalsecurity.org/military/systems/ground/fbcb2.htm 24 February 2006.

transmitters send digital data to a central control station, where the operator uses a laptop with software designed to display mortar, rocket, and artillery points of origin (POO) and points of impact (POI). UTAMS is one of several systems that are being used to compliment Counter Rocket, Artillery and Mortar (CRAM) systems, and are designed to protect forward operating bases and headquarters facilities from attack.

UTAMS has also proven successful in determining the location of Improvised Explosive Device (IED) explosions. In one example, an IED exploded approximately 10 km away from a UTAMS device and the location was sent to the overhead camera, which tracked an insurgent to his house in the second floor of the building. Iraqi local security forces were then called to respond to the attack and went to the house. The overhead surveillance cameras were able to keep the insurgent in sight as he paced through his upstairs apartment, and watched as the security forces came to his door. He was seen talking to the security forces and then immediately arrested. So, it is clear that the technology being used by today’s armed forces is much better at locating enemy activity, so that either US or Iraqi forces can take the appropriate action.

Two other unique aspects of the UTAMS is that it can be used for pattern analysis to assist in base security plans, based on the historical data that it collects from the local area. Once a pattern of activity is studied, base security can be adjusted and offensive actions can be taken. Also, since the system is relatively new, forces in theater can send data from the system back to CONUS to help determine how to fix problems with the software. No longer do you have to pack up a piece of equipment and send it through a long and drawn out logistical process. Engineers in the lab back in the states can look at what’s going on with the data and interface with personnel using email to do the trouble shooting.

The UTAMS is the perfect example of how rapid fielding initiatives can get solutions to the warfighter in an extremely short timeframe, using the operational commander’s near term requirements process. Once a requirement is identified, commanders interface with a Field Assistance in Science and Technology (FAST) team that contact the research lab, and they start

working on a solution using Commercial Off The Shelf (COTS) technology. In the case of the UTAMS, this was conducted successfully in three months, and now there are over 30 systems serving US forces based on additional Operational Needs Statements (ONS) from the field.[38]

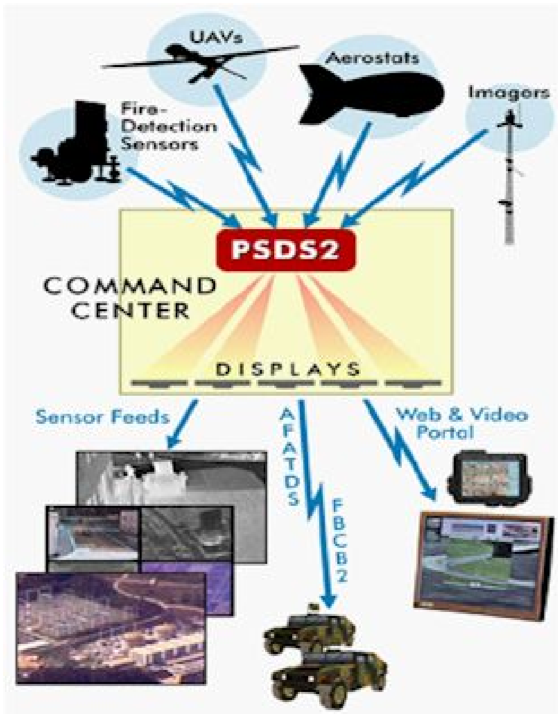

Figure 17-PSDS2 Network Concept

Photo: APM Persistent Surveillance Systems. Online @

https://peoiewswebinfo.monmouth.army.mil/portal_sites/IEWS_Public/rus/PSDS2.htm

Persistent Surveillance Dissemination System of Systems (PSDS2) is a networked system integrating ISR assets in real time, providing video and fused information for display in the command center and dissemination of actionable intelligence to commanders in the field. It takes digital information from UAVs, aerostats, firefinder radar, and fixed imagers and processes the information into a picture or video that provides "unprecedented situational awareness" to the headquarters and subordinate units. A unified geo-referenced view, where every pixel on the

[38] Regan Edens, GS-15 in support of ARL. Interview by author. Fort Sill, OK., 5 October 2005.

screen has a GPS coordinate, provides much better precision for decisions and actions. Live video and airborne sensor feeds are overlaid on a terrain model to provide 3D context, and designated users can view data using handheld devices or laptop computers. This system will eventually incorporate a version of the Navy's Phalynx gun, an automatic, rapid fire, autonomous system that will be able to engage mortars and artillery shells that threaten friendly forces. Fire support and force protection are finally entering the information age, and digital systems are taking US forces to the prime time of joint fires, where all fire support and strike capabilities can be employed with much better precision based on much better knowledge.

Joint Organizations: Integrating C4ISR Capabilities

Figure 18-CENTCOM Joint Intelligence Center

Photo: Brook Kraft/Corbis. Online @

http://www.cia.gov/csi/studies/vol49no1/html_files/the_evolution_6.html#author

The Joint Intelligence Center (JIC) is a Combatant Command intelligence fusion center of excellence that is responsible for providing and producing the intelligence required to support that headquarters as well as the command's components, subordinate joint forces and elements, and the national Intelligence Community. The goal is to have a fully functional JIC at each combatant command by mid-2006. JIC-level analytical expertise is particularly critical for

today's counterterrorism operations. While transnational organizations, such as al-Qa'ida, are best tracked and assessed at the national level, the increasing trend toward franchise terrorist operations and splinter groups has reinforced the need for counterterrorism expertise and databases at the theater level. This same requirement has driven the establishment of Joint Inter-Agency Coordination Groups (JIACGs) at the theater commands, bringing together multiple organizations besides the military to plan and execute counterterrorism operations.[39]

Joint forces operating in both Afghanistan and Iraq have demonstrated the efficacy of modern C4ISR systems, empowered by space, air, and sea superiority, to take the fight to the enemy in austere environments using a much smaller ground capability. The SOF-and coalition ground force required less logistics and build-up time than previous wars, which is en example of how the power of technology, combined with changes in the organization, create a synergistic effect. Improvements to existing systems and organizations has also increased effectiveness of target acquisition and decreased kill chain time. During OIF I the capabilities of joint forces to achieve quick air superiority, followed by total control of the electromagnetic spectrum in areas to the West of Baghdad provided the deception that caused Saddam Hussein to think that a major attack was coming from the West or North. This caused him to move significant forces away from the main Fifth Corps attack and contributed to the rapid advance of joint forces.

As the GWOT continues to progress, it is increasingly apparent that the ability to gather intelligence using both technological and human means is critical to preventing another catastrophic attack in the US. It is also apparent that Al-Qaeda, splinter groups, and the insurgents fueling civil war in Iraq are capable of adapting to remain effective. As the US pulls forces out of Iraq and refocuses its efforts to other parts of the Middle East, C4ISR and continuous improvement in digital technology will continue to enable and empower joint forces

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[39] James D. Marchio, "The Evolution and Relevance of Joint Intelligence Centers", *CIA.gov.* Accessed online at http://www.cia.gov/csi/studies/vol49no1/html_files/the_evolution_6.html 14 February 2006.

to accomplish their missions in the GWOT. The next chapter describes some of the future systems that will enable the warfighter, and provide the technological advantage that is required by the joint vision and network-centric warfare concepts.

CHAPTER FOUR

FUTURE C4ISR CAPABILITIES

MILSATCOM: Wideband Gapfiller Satellites (WGS) and Transformational Satellite (TSAT)

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Figure 19-WGS Satellites

Photo: Boeing. Online @ www.boeing.com/defense-space/space/bss/factsheets/702/wgs/wgs_factsheet.html

The Wideband Gapfiller Satellites (WGS) are the next generation of advanced extremely high frequency MILSATCOM systems that will provide a quantum leap in communications capabilities for the warfighter. WGS will support the DoD's warfighting information exchange requirements, enabling execution of tactical C4ISR, battle management, and combat support

information. Boeing Integrated Defense Systems, a unit of the Boeing Company, has been awarded contracts by the Air Force for three currently funded systems valued at $300 million each. WGS satellites will provide service in the X and Ka band frequency spectrums, and will augment the current X-band Defense Satellite Communications System (DSCS) and Ka-band Global Broadcast Service (on UHF F/O satellites), by providing additional communications and information broadcast capabilities. The first two satellites are scheduled for launch in FY 2006, a third in FY 2007, and two additional systems are planned in the next few years. WGS is a multi-service program managed by the US MILSATCOM Joint Program Office (MJPO) at the Space and Missile Systems Center, Los Angeles Air Force Base, California.

The 2006 QDR provides guidance on implementing the Transformational Satellite (TSAT) program under the Transformational Communications Architecture, or TCA. The decision to "spiral" the latest technologies into the multi-billion dollar program indicates that TSAT will proceed in order to provide the needs of the network-centric force. According to the *Defense Industry Daily*, TSAT "is intended to provide internet-like capability that extends high-bandwidth satellite capabilities to deployed troops worldwide, and delivers an order of magnitude increase in available military bandwidth. Using laser communications and inter-satellite links to create a high data-rate backbone in space, TSAT will be one of the key enablers for the American vision of Network Centric Warfare. A visual image from a UAV that would take 2 minutes to process with the Milstar II satellite system would take less than a second with TSAT. A radar image from a Global Hawk UAV (12 minutes), or a multi-gigabyte radar image from space-based radar (88 minutes), would also take less than a second with the TSAT network. Best of all, the recipient can be on the move with a relatively small receiver, anywhere in the world."[40] The

[40] "Special Report: The USA's Transformational Communications Satellite System (TSAT)", *Defense Industry Daily*, 19 July 2005. Accessed online at http://www.defenseindustrydaily.com/2005/07/special-report-the-usas-transformational-communications-satellite-system-tsat/index.php 23 March 2006.

overall TSAT system will include the TSAT Space Segment (TSAT SS) satellites, and the integrated ground station segments and networks.

Figure 20-AT&T Global Network Operations Center

Photo: AT&T. Online @ http://www.hok.com/Projects/SelectedProjects/9F560106-8EA0-46CB-AF04-498F27EA234D/AT_T_Global_Network_Operations_Center_DotComWeb.htm?sort=Alpha

One of the most important aspects of the Transformational Satellite Architecture will be the TSAT Mission Operations System (TMOS) ground segment portion. The TMOS network will provide the military with a global broadband, on-demand, Internet Protocol capability that connects the space segment to the Global Information Grid. Lockheed Martin was awarded the contract this year by the Air Force for $2.02 billion, and the global network is projected to be fully operational in the 2015 timeframe. The picture above, which shows the AT&T Global Network Operations Center, or GNOC, is illustrative of what the Air Force and Lockheed Martin have in mind for the TMOS concept. This is just another example of how the digital revolution within the business sector is impacting the military. By the time all the millions of lines of code are written for the software, and with the dramatic pace of innovation in digital technology systems, the final product of the military's TMOS facilities will surely be the most cutting-edge systems on the planet. The partnership with industry is of course the critical and most important

aspect, since this is where the ideas and capital are flowing. Industry is also the model for cost, since profit-centered approaches must be efficient to be successful.

New Overhead Imagery Systems: Space Radar program

Figure 21-Future Space Radar Satellite

Photo: DOD. Online @ www.comw.org/qdr/qdr2006.pdf

Another decision specified in the 2006 Quadrennial Defense Review (QDR) is to implement a new imagery intelligence methodology that is focused on providing persistent collection capabilities in cooperation with the Director, National Intelligence. Future investments in moving target indicator and synthetic aperture radar capabilities, including the new Space Radar system, will be increased so that highly persistent surveillance capabilities will enable joint forces to identify and track moving targets in denied areas. The system will be capable of performing in all weather conditions, during day or night conditions.[41] The QDR also highlights the importance of balancing the capabilities of air and space ISR assets, expanding the integration of these capabilities with other forces, and continuing to investigate the use of high-altitude loitering capabilities. This means that C4ISR space and air systems will continue to be funded

[41] Department of Defense, "Quadrennial Defense Review Report", 3 February 2006, *Defenselink.mil*. Accessed online at http://www.defenselink.mil/qdr/report/Report20060203.pdf 28 February 2006.

and integrated into the joint force, as well as ensuring that the interagency collaboration is established within each theater's Joint Intelligence Centers.

Manned/Unmanned Aerial Systems: Cormorant, P-8A Multi-mission Maritime Aircraft (MMA)

Figure 22-Submarine-launched "Cormorant" UAV

Photo: DARPA. Online @ www.darpa.mil/tto/programs/cormorant.htm

Lockheed Martin and DARPA are working on an experimental submarine launched UAV that can be equipped with surveillance and weapons systems. If fully developed, the system will provide the capabilities of an armed Predator, only it will be stealthily launched from an Ohio class Trident missile submarine. These submarines are also equipped with SEAL delivery vehicles, so the Cormorant UAV would provide an additional C4ISR system for missions near coastlines. Once a mission is complete, the Cormorant would return to the sea to rendezvous with the submarine and be retrieved. This is an example of how digital C4ISR technology is being used to enable covert and strike operations from a former nuclear capable platform. It shows how the value of nuclear systems is being replaced with the value of C4ISR systems, that can enable the warfighter to meet the requirements of the GWOT.[42] So even though the Joint Unmanned

[42] Bill Sweetman, "The Navy's Swimming Spy Plane", *Popular Science*, March 2006.

Combat Aerial System (JCAS) may have been put on hold by the QDR, it seems that the Navy will still continue to pursue their own UAV capability in order to meet C4ISR requirements.

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Figure 23- P-8A Multi-Mission Aircraft (MMA)

Photo: Boeing. Online @

www.boeing.com/companyoffices/gallery/images/military/mma/mmaphotos.html

The P-8A Multi-mission Maritime Aircraft (MMA) is the replacement for the P3 Orion. The initial low rate production is scheduled to begin in 2008, with initial operating capability in 2013. Approximately 108 of these aircraft are being built by Boeing and a team of industry leaders, including Raytheon and Northrop Grumman at a cost in the 40-plus billion-dollar range. The design is based on a 737-800 air frame, with a fuselage built in Wichita, Kansas before being shipped to Renton, Washington for all unique fabrication and assembly. The P-8A MMA will use its extensive EO/IR and SIGINT capabilities to search for and destroy submarines, monitor sea traffic, launch missile attacks on naval or land targets as required, and perform an electronic intercept role. This will involve carrying sonobuoys, torpedoes, depth charges, Harpoon anti-shipping missiles, SLAM land attack missile, and other weapons, as well as advanced sensors, communications, and other electronics. The program goal is a modern, highly reliable airframe that will be equipped with improved maritime surveillance and attack capability, allowing a

smaller force to provide worldwide responsiveness on a smaller support infrastructure.[43] This system will be a key component for the US Navy's Sea Power 21 doctrine, Sea Shield concept, and FORCEnet architecture for the Common Underwater Picture (CUP). As a secondary role, it will support Sea Strike doctrine, using its extensive ISR capabilities for delivery of sea and surface attack missiles.

Aerostats: Joint Land Attack Cruise Missile Defense Elevated Netted Sensor (JLENS) System

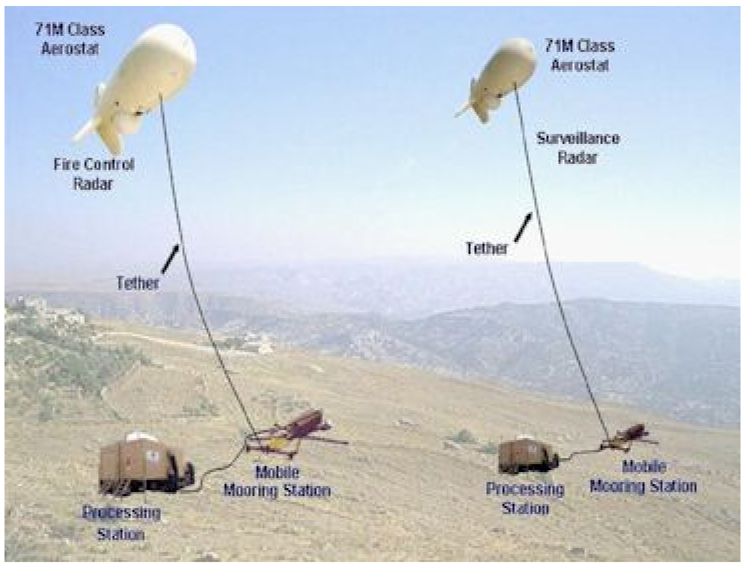

Figure 24-JLENS Concept

Photo: Defense Industry Daily. Online @ http://www.defenseindustrydaily.com/2005/11/jlens-ramps-up-hard-raytheon-wins-13b-contract/index.php

The JLENS system is an elevated aerostat system developed by Raytheon, which uses an advanced sensor array to improve wide area protection against land attack cruise missiles. It is an affordable system, can provide 30 days coverage, and look over the horizon for threats. The

[43] "P-8A MMA Could Become a Multinational Program (Updated)", *Defense Industry Daily*, 10 May 2005. Accessed online at http://www.defenseindustrydaily.com/2005/05/p8a-mma-could-become-a-multinational-program-updated/index.php 28 February 2006.

JLENS system provides real-time situation awareness for attack operations, as well as another communications link on the joint digitized battlefield. Optional additional payloads may include electronic intelligence and communications intelligence (ELINT and COMINT) sensors and Blue Force Tracker capabilities.[44] The Army awarded Raytheon a contract of 1.3 billion dollars in November 2005, following successful operational testing in theater, with approximately 12 complete systems due out between 2009 and 2011.[45]

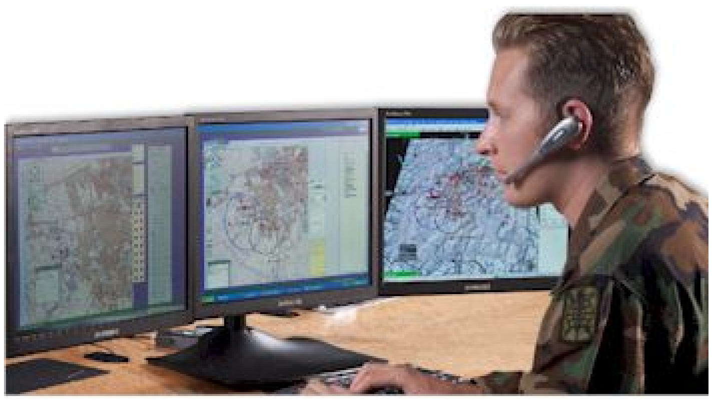

Figure 25-Command Post of the Future (CPOF)

Photo: General Dynamics. Online @ www.gdc4s.com/cpof

CPOF is an executive level decision support system that provides collaborative planning and situational awareness capabilities. Operations can be planned and coordinated using two-dimensional and three-dimensional graphics, voice over internet protocol (VOIP), and click and drag functions across three flat panel screens. CPOF is a Defense Advanced Research Projects Agency (DARPA) technology development program being built by General Dynamics, and is scheduled to be handed over to the Army in 2006. The idea behind the system is to allow

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[44] Raytheon, "JLENS Product Data Sheet", *Raytheon.com*, April 2005. Accessed online at http://www.raytheon.com/products/stellent/groups/public/documents/legacy_site/cms01_048578.pdf 12 February 2006.

[45] Robert Weisman, "Raytheon wins $1.3b Pact", *Boston Globe*, 15 November 2005. Accessed online at http://www.boston.com/news/globe/reprints/111505_rweisman/ 23 February 2006.

commanders more freedom to move around the battle space without being tied to a headquarters for updates or planning processes. The capabilities of handheld wireless devices, rugged laptop computers, SATCOM, and VOIP allows commanders the ability to go where they want, when they want, and when planners or staff need to reach the commander they can use any number of devices to do so. Information about the next 72 hours or next operation can be sent instantly to a commander's aircraft, vehicle, or portable device to keep him or her informed and to provide feedback or decisions to the headquarters. In the same capacity, the technology is a more efficient means for commanders to communicate with higher or lower levels of command, so that they don't need to attend the next briefing in person, but can collaborate with other commanders from where they choose.

With the establishment of the Global Information Grid (GIG) in the next few years, the communications capabilities of the military and homeland defense will truly be seamless, providing freedom to act virtually anywhere at anytime as required by the situation. During the recent congressional investigation into the Hurricane Katrina response, one of the key findings as to why the government did not respond effectively initially was that key leaders could not communicate with each other. Michael Brown was flying over the disaster area and Michael Chertoff could not reach him for an extended period of time, therefore, critical communication between two key leaders did not occur, much less collaboration between planners of different organizations. Once a worldwide internet and communication capability exists, and the appropriate C4ISR equipment is integrated at every organizational level, then there is a much better likelihood of efficiency and effectiveness to occur.

The period of time that Knox and Murray refer to before a transformation or revolution in military affairs can occur is nearly at hand. The US is nearly at the inflection point where once the digitization of all aspects of the government and the military are brought up to a certain level, then truly effective organizational change will produce the technological synergy to respond to threats in the GWOT or from nature. Does this mean that the information and digital age will be

perfect? Absolutely not. However, if the old saying that "knowledge is power" has any truth or meaning behind it, then there is a much better chance that the "fog of war" and the complexity of the contemporary operating environment can at least be tamed and managed in a much better way. Therefore, as complexity increases in the world, technological and organizational change enabled by C4ISR and digitization will empower individuals within organizations to act.

This chapter has described some of the latest innovations and concepts in the C4ISR arena. It should be fairly clear to the reader that network-centric operations are happening right now, and that funding will continue to drive the R&D and Industrial community to bring even more advanced solutions to the joint warfighter. As the space communications backbone is put into place for global network-centric operations, and advanced manned and unmanned systems are integrated into the force, it will be increasingly important to educate leaders at every level on the concepts and capabilities of these systems. The current American generation has merely scratched the surface into employing digitally-enhanced C4ISR capabilities. The generation that joins the joint force in 2012-2015 are destined to be the most technologically enhanced and the most digitally savvy group ever to put on a US uniform. Once Future Combat Systems comes on-line, as well as advances in mobility platforms, the digitally enhanced joint force will be a more flexible and adaptable force, that can provide relevant and lethal capabilities wherever they are needed in the world.

CHAPTER FIVE

CONCLUSION

The investment being made by all the services and national intelligence agencies regarding C4ISR systems are indicative of a trend that started during the Cold War, and that has risen to be the key component of transformation. This paper has attempted to explain the impact that culture, industry, politics and threats to the nation have had towards a reliance on technology within the military. The theories of technological determinism and social construction seem to fall short in explaining whether the development of a new technology has led change, or if social and organizational design provides the foundation for technological change. Rather, a theory of technological synergy combining technological development and organizational design provides a more complete explanation of military transformation in the twenty first century. The development of digital C4ISR systems combined with changes in the organization have empowered the US to deploy joint forces rapidly and in new ways, incorporating new operational concepts to meet new threats in the GWOT. The fact that every unit in the military is not fully digitized as of yet, with the ability to communicate seamlessly, achieve real-time situational awareness, and tap into all the tools available in the C4ISR architecture does not necessarily mean that a change has not occurred. Because by the time every unit achieves this level of transformation, there will already be new advances in software and hardware that has been spiraled into the force.

The challenge will be in how the management of technology is conducted, along with adapting and changing the organizational behavior in new ways that are best designed to use a developing technology. These are necessary and important concepts that must be continually studied and understood, since it is only through a healthy and open dialogue between researchers, industry, leadership, and operators that truly effective solutions will be achieved. As discussed

earlier, there will be cases of failure due to an inability to communicate new concepts, resulting in a waste of resources and possibly even some confusion in the education system. But these types of setbacks should not deter or hinder the process of innovation and transformation. On the contrary, they should serve as examples of how change is not easy, and that it is necessary to meet the challenges of the contemporary operating environment through continual improvement in dialogue and learning processes. The concept of the learning organization that understands not only what to learn, but how it learns is required in order to meet the goal of an adaptive or organic organization that is relevant and ready, rather than a beaurocratic and static organization that merely reacts to change.

The terrorist organizations that threaten the US and its allies are constantly changing the ways and means that they plan and conduct operations, so it is critical that the joint forces continue to adapt, in order to defeat these fluid and evolving organizations before they can gain the initiative. Operations in Iraq and Afghanistan clearly show that the US is very good at rapid and decisive maneuver against an inferior conventional foe, however, defeating an insurgency and tracking down splinter terrorist cells has proven to be more of a challenge. The very nature of irregular warfare indicates that these groups will take their time, gain more recruits and strength, develop new tactics, and strike at the time of their choosing. Also, the requirement to build-up the infrastructure, governance, and security apparatus in developing countries like Iraq and Afghanistan is not a quick or easy process. Therefore, senior US military and civilian leaders are starting to adopt a more long-term strategy, and are beginning to formulate a strategy that can address the likelihood of a long war. If this assessment is correct, then the ability of joint forces to stay ahead of the enemies' decision cycle has to be achieved through superior information and intelligence. The warfighter needs every advantage possible, and C4ISR that is on demand and flexible can provide that advantage.

As Sun Tzu wrote over 2500 years ago, the most important factor in defeating the enemy is the ability to understand what the enemy is going to do. The superior General does not act

without first knowing that he will win. In order to achieve superior information and intelligence, the US must continue to develop robust C4ISR capabilities that can be tailored and adapted to the situation. This can be achieved through current and future technology, as well as strategic and organizational design that fosters collaboration between respective law enforcement, government agencies, allies, and non-governmental organizations. In many cases, such as CENTCOM and PACOM, the investment in C4ISR and intelligence fusion capabilities is paying off, which is why almost every other combatant command will have the same type of capabilities this year. Once all joint forces and interagency organizations are fully capable of plugging into the capabilities of a global C4ISR architecture, the benefits of technological and organizational change will reach their full potential.

BIBLIOGRAPHY

Abizaid, John P. GEN (USA). *2005 Posture of the United States Central Command*. Statement before the House Armed Services Committee, 2 March 2005. Online @ (http://www.house.gov-hasc-openingstatementsandpressreleases-108thcongress-04-03-11mosely)

Associated Press. "Report: Army could be near breaking point", *MSNBC*, 24 January, 2006. Accessed online at http://www.msnbc.msn.com/id/11009829/ 25 January 2006.

Barber, Benjamin R., *Fear's Empire: War, Terrorism and Democracy* (New York: Norton, 2003).

Brinkley, Alan. American History, A Survey. Volume 1 & 2, 9th ed, (New York: McGraw-Hill, 1995).

Boeing, "E-3 AWACS", *Boeing Link*, February 2006. Accessed online at http://www.boeing.com/defense-space/infoelect/e3awacs/ 17 February 2006.

Boeing, "GPS IIF/III", *Boeing Integrated Defense Systems*, February 2006. Accessed online at www.mdc.com/defense-space/space/gps/m_gen.html 17 February 2006.

Boeing, "Grenadier BRAT", *Boeing Integrated Defense Systems*, February 2006. Accessed online at http://www.boeing.com/defense-space/ic/grenbrat/index.html 24 February 2006.

Bush, Vannevar, "As We May Think", *The Atlantic Monthly*, July 1945. Accessed online at http://www.theatlantic.com/doc/194507/bush, 29 January 2006.

Congressional Record, *Intelligence Authorization Act of Fiscal Year 1996* (Wahington D.C.: US Senate, 29 September 1995). Accessed online at http://www.fas.org/irp/congress/1995_cr/sen29sep.htm 24 February 2006.

Corbett, Julian S., *Some Principles of Maritime Strategy* (Annapolis, MD: Naval Institute Press, 1988).

Cordesman, Anthony H., *The Ongoing Lessons of Afghanistan* (Washington D.C.: Center for Strategic and International Studies, 6 May 2004), 37.

Cordesman, Anthony H. *The Lessons of the Iraq War: Main Report.* (Washington D.C.: Center for Strategic and International Studies, 21 July 2003).

Department of Defense, "Quadrennial Defense Review Report", 3 February 2006, *Defenselink.mil*. Accessed online at http://www.defenselink.mil/qdr/report/Report20060203.pdf 28 February 2006.

Director, Force Transformation, *The Implementation of Network-Centric Warfare*, Office of the Secretary of Defense, 5 January 2005.

Edens, Regan, GS-15 in support of ARL Interview by author. Fort Sill, OK., 5 October 2005.

"Force XXI Battle Command, Brigade and Below (FBCB2)", *Global Security*, February 2006. Accessed online at http://www.globalsecurity.org/military/systems/ground/fbcb2.htm 24 February 2006.

Friedman, Thomas L. *The World is Flat: A Brief History of the Twenty-first Century* (New York: Farrar, Straus and Giroux, 2005).

Gearty, Michael J. *Lessons Learned: Task Force Sentinel Freedom OEF/OIF*. Military Intelligence Professional Bulletin, Oct-Dec 2003.

General Atomics/USA, “RQ-1A/MQ-1 Predator”, *Defense Update: International Online Defense Magazine*, 2005, Issue 2. Accessed online at http://www.defense-update.com/products/p/predator.htm 1 February 2006.

Henry, Ryan and Peartree, Edward C. *Military Theory and Information Warfare*, Parameters, pp. 121-135, Autumn 1998.

Hoffer, Eric, The True Believer (New York: Harper and Row Publishers, 1951), Preface, ix.

Huntington, Samuel, *The Clash of Civilizations and the Remaking of World Order* (New York: Touchstone, 1996), 28.

Hutschnecker, Arnold A. *The Drive for Power*, (New York: M. Evans and Company, Inc., 1974).

Ickenberry, G. John, “Illusions of Empire: Defining the New American Order”, *Foreign Affairs*, March/April 2004. Accessed online at www.foreignaffairs.org 26 January 2006.

Internet Society, “A Brief History of the Internet”, 10 December 2003. Accessed online at http://www.isoc.org/internet/history/brief.shtml, 11 February 2006.

Jones, James L. GEN (USMC), *EUCOM Theater C4ISR*.. Statement before the Senate Armed Services Committee, 1 March 2005.

Kinicki, Angelo and Kreitner, Robert. *Organizational Behavior: Key Concepts, Skills and Best Practices*, New York: The McGraw-Hill, 2003.

Klein, John J., “Corbett in Orbit: A Maritime Model for Strategic Space Theory”, *Naval War College Review*, Winter 2004.

Knox, MacGregor and Murray, Williamson, *The Dynamics of Military Revolution* (New York: Cambridge University Press, 2001), 179-180.

Lockheed Martin, “ Milstar satellite overview”, *Spaceflight Now*, 1 April 2003. Accessed online at http://www.spaceflightnow.com/delta/d300/ 5 February 2006.

Mann, Michael, *Incoherant Empire* (New York: Verso, 2003).

Marchio, James D., “The Evolution and Relevance of Joint Intelligence Centers”, *CIA.gov*. Accessed online at http://www.cia.gov/csi/studies/vol49no1/html_files/the_evolution_6.html 14 February 2006.

Marx, Leo and Smith, Merritt Roe. *Does Technology Drive History? The Dilemma of Technical Determinism*. (Cambridge, MA: Massachusetts Institute of Technology, 1995), 4.

Moseley, Michael T., General, *Congressional Testimony on the Adequacy of the Fiscal Year 2005 Budget to meet Readiness Needs* (Washington D.C.: House Armed Services Committee, March 11, 2004). Accessed online at http://www.house.gov/hasc/openingstatementsandpressreleases/108thcongress/04-03-11moseley.html 3 February 2006.

Office of the Press Secretary, *State of the Union: The Advanced Energy Initiative* (Washington D.C.: White House, 31 January 2006). Accessed online at http://www.whitehouse.gov/news/releases/2006/01/20060131-6.html 17 February 2006.

"P-8A MMA Could Become a Multinational Program (Updated)", *Defense Industry Daily*, 10 May 2005. Accessed online at http://www.defenseindustrydaily.com/2005/05/p8a-mma-could-become-a-multinational-program-updated/index.php 28 February 2006.

Raytheon, "JLENS Product Data Sheet", *Raytheon.com*, April 2005. Accessed online at http://www.raytheon.com/products/stellent/groups/public/documents/legacy_site/cms01_048578.pdf 12 February 2006.

Space Operations Office, *US Army Space Reference Text* (Fort Leavenworth, KS: Command and General Staff College, December 2004).

"Special Report: The USA's Transformational Communications Satellite System (TSAT)", *Defense Industry Daily*, 19 July 2005. Accessed online at http://www.defenseindustrydaily.com/2005/07/special-report-the-usas-transformational-communications-satellite-system-tsat/index.php 23 March 2006.

Sweetman, Bill, "The Navy's Swimming Spy Plane", *Popular Science*, March 2006.

Tapscott, Don. Growing Up Digital: The Rise of the Net Generation. New York: McGraw-Hill, 1998.

Teets, Peter (The Honorable), *MILCOM 2003 Luncheon Address.* National Reconnaissance Website, 16 October 2003. Online @ (http://www.nro.gov/index.html).

The National Geospatial-Intelligence Agency, Factsheet, February 2006. Accessed online at http://www.nga.mil/portal/site/nga01/index.jsp?epi-content=GENERIC&itemID=31486591e1b3af00VgnVCMServer23727a95RCRD&beanID=1629630080&viewID=Article 28 February 2006.

US Air Force, "Global Hawk", *Air Force Link*, February 2006. Accessed online at http://www.af.mil/factsheets/factsheet.asp?fsID=175 12 February 2006.

US Air Force, "JSTARS", a*irforce-technology*, February 2006. Accessed online at http://www.airforce-technology.com/projects/jstars/ 17 February 2006.

US Air Force, "RC-135 V/W Rivet Joint", *Air Force Link*, February 2006. Accessed online at http://www.af.mil/factsheets/factsheet.asp?fsID=121 24 February 2006.

Van Riper, Paul, LTG(R) "Concerns", email to CJCS, 11 December 2005. Forwarded from SAMS Information Technology Coordinator, 10 January 2006. Available on request from author.

Weisman, Robert, "Raytheon wins $1.3b Pact", *Boston Globe*, 15 November 2005. Accessed online at http://www.boston.com/news/globe/reprints/111505_rweisman/ 23 February 2006.

Wolf, Jim, "Lockheed to get U.S. spy-plane scrapping fees", Reuters, 16 January 2005. Accessed online at http://finance.myway.com/jsp/nw/nwdt_rt_top.jsp?cat=TOPBIZ&feed=bus&src=202&section=news&news_id=bus-n16141591&date=20060116&alias=/alias/money/cm/nw 16 January 2006.

Wurster, Donald BG(USAF), *2005 Tactical Intelligence and Related Activities (TIARA) and Joint Military Intelligence Program (JMIP) Budget Requests*, Statement before Strategic Forces Subcommittee for the Senate Armed Services Committee, 7 April 2004.